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The determinants of ICT: an empirical study for the G8

Abstract

Information and communication technologies (ICT) are a rapidly growing area of the economy that are crucial to economic growth and present new opportunities. Using time series econometrics on a panel of G8 developing nations, this study illustrates how ICT affects economic growth.

The findings indicate that ICT and economic growth have a beneficial, long-term link. By demonstrating the existence of unidirectional causality, Granger causality analysis enables us to make the claim that investments in ICTs drive economic growth rather than the other way around. Therefore, the G8 nations have a chance to promote sustainable economic growth through the advancement of ICT.

Keywords: Economic growth, ICT, R&D, Causality, G8.

1/Introduction

Technology for information and communication (ICTs) is crucial to the "new knowledge economy." (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Brynjolfsson and Hitt, 2011; Bassanini and Scarpetta, 2002; OECD, 2004; Timmer and van Ark, 2005; Holt and Jamison, 2009; Kretschmer, 2012; Biagi, 2017) Several studies have demonstrated the importance of ICTs, innovation, and technological change as determinants of productivity and national growth. ICT has a stronger effect on growth at the business level than at the industry and national levels, according to other studies (Lehr and Lichtenberg, 1999; Brynjolfsson and Hitt, 2000, 2003; Matteucci et al., 2005).

Product design, marketing, production, funding, and organization have all improved as a result of businesses using ICT (Hollenstein, 2004; Bloom et al., 2013). Additionally, by encouraging the development of new goods and services, ICT typically fosters innovation (Becchetti et al., 2003; Carlsson, 2004; Hollenstein, 2004).

These days, it is simple to understand how ICT determinants, especially R&D and education spending, affect the performance of enterprises in industrialized nations. Information and

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communication technologies are quickly expanding in poor nations, per a recent World Bank research. Information and communication technologies provide developing countries (DCs) with access to the knowledge domain and the ability to foster economic growth, according to a number of studies (Steinmueller, 2001; Lal, 2004; Basant et al., 2011; Tello, 2013; Calza and Rovira, 2011; Gutiérrez, 2012; Akomea-Bonsu, 2012).

Although the factors influencing ICT are mainly explained in developed nations, ICTs in developing nations exhibit systemic features since their adoption is constrained by a different environment than in developed nations. The infrastructure that is available, the caliber and accessibility of skilled workers, the size of the national market, the market's openness, the organization's and production plans' flexibility, the company's size, and the manager's reputation are all areas where these disparities exist.

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2/ Literature Review

An economy is built on the knowledge-based Information and Communication Technologies (ICT). ICT, innovation, and technological change are seen by many researchers as factors that influence efficiency and growth (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Brynjolfsson and Hitt, 2000; Bassanini and Scarpetta, 2002; OECD, 2004; Timmer and van Ark, 2005; Holt and Jamison, 2009; Kretschmer, 2012; Biagi, 2017). According to Lehr and Lichtenberg (1999), Brynjolfsson and Hitt (2000, 2003), and Matteucci et al. (2005), their influence on growth and productivity is stronger at the business level than it is at the industry and national levels.

Product creation, marketing, production, financing, and organization are all improved by the usage of ICT in businesses (Hollenstein, 2004; Bloom et al., 2012). ICT, according to Becchetti et al. (2003), Carlsson (2004), and Hollenstein (2004), is synonymous with innovation and makes it easier to develop new goods and services. The performance of industrialized nations is undoubtedly impacted by ICT investment,

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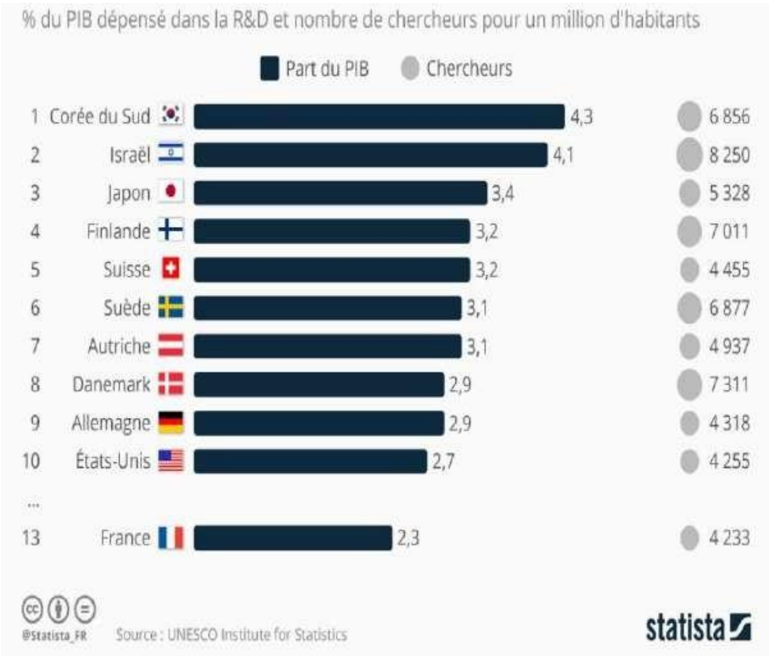
especially when it is coupled with changes in organizational and human resources (Milgrom and Robert, 1995; Greenan et al., 2001; OECD 2003; Bloom et al., 2012; World Bank, 2016). Below is a presentation of the countries that invest the most in R&D worldwide:

Figure 1: The world's leading R&D countries



The most recent UNESCO data indicates that R&D investments are South Korea's area of expertise. Although the nation spends 4.3% of its GDP on research & development, this amount only amounts to 2.3% of GDP, placing France in 13th place by this metric.

Figure 2: Business R&D expenditures in Canada and other OECD countries as a percentage of GDP, 2015 or most recent year (%)

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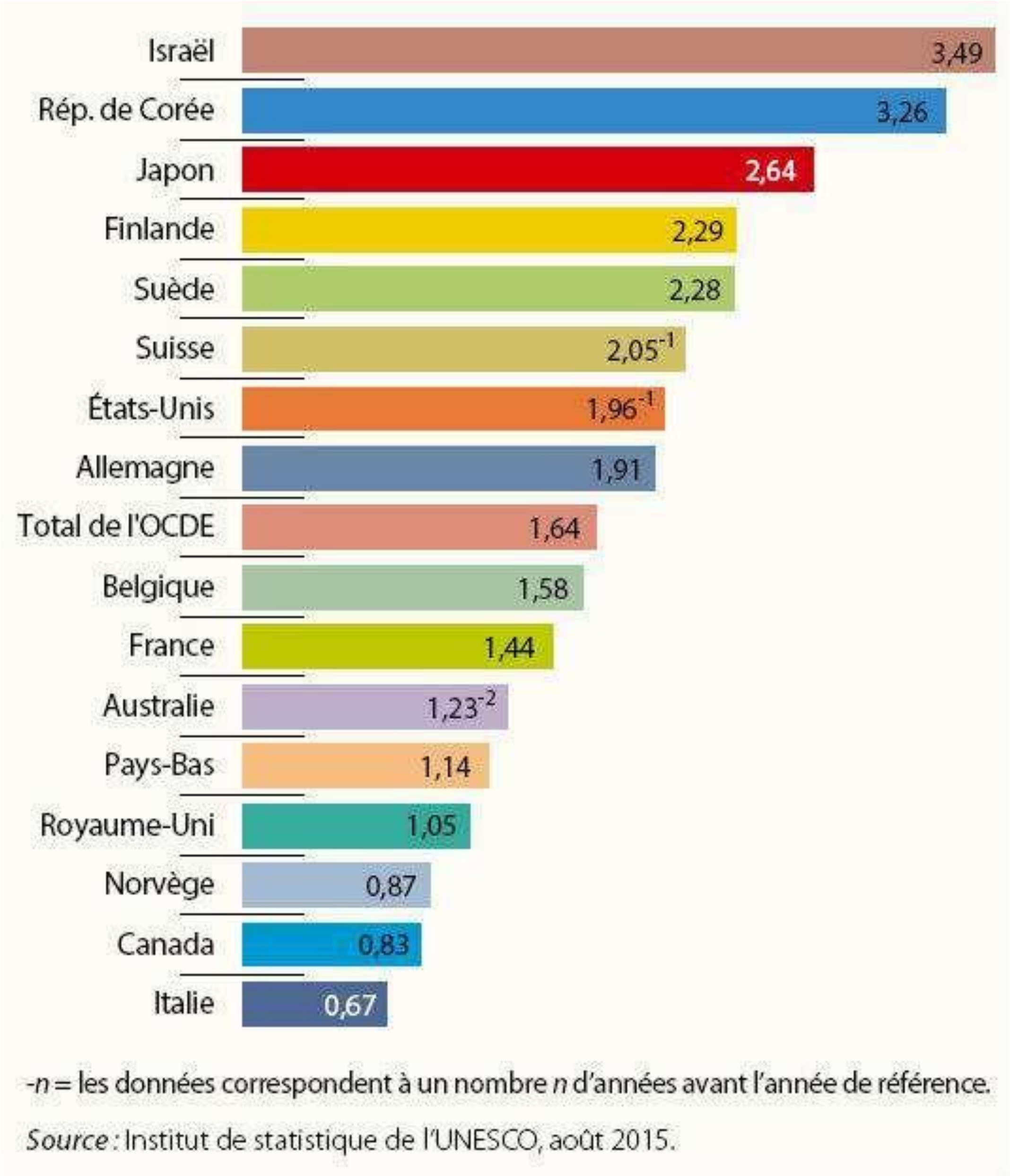

Prior to the drop-in oil and other commodity prices in 2014, the post-crisis era was comparatively straightforward for nations with an abundance of commodity resources, such as Canada and Russia. New growth engines are desperately needed.

Japan outperformed the main advanced economies (G8) in terms of GDP share in 2015. It is still one of the few significant advanced economies, nevertheless. Japan is taking action to strengthen industry-academia ties and capitalize on these industrial advantages in the domains of ICT, energy, and pharmaceuticals since it is especially worried about the downward trend in its private sector R&D investment.

In comparison, Italy's R&D spending as a proportion of GDP is merely 0.67%, whereas Japan's amounts reach 2.64%.

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The G8 will continue to report increases in economic output and R&D spending, making them some of the most inventive nations in the world. Germany stayed near 0.83 in 2015, and just three member states—Japan, the US, and Germany—made significant investments.

According to Benoit (1978), research on the correlation between economic growth and defense spending distribution indicates that nations with the highest defense spending tend to have the fastest rates of growth, while those with the lowest defense spending typically have the slowest rates. According to Benoit (1978), defense spending has a positive impact on economic growth. "Most countries' defense plans have made tangible contributions to the civilian economy in the following ways:

Some people need to be fed, clothed, and housed; otherwise, the civilian economy would have to provide these necessities, especially in less developed nations. This implies that, similar to other consumption guidelines, their nutritional intake is significant.

- delivering medical treatment, education, and vocational technical training (such as in construction techniques, hygiene and medical care, or the operation and repair of cars, airplanes, and radios), which may be of a civilian character;
- It is expected that citizens will gain in part from the construction of various public works, such as highways, dams, river repairs, airports, communications networks, etc.
- Engage in quasi-civilian tasks like coast guard, lighthouse operations, customs, border guards, and disaster relief, as well as scientific and technical competence like research, graphics, cartography, dredging, meteorology, soil and water conservation, and forestry projects. Otherwise, personnel must give civilian relief. Additionally, the military conducts some research and development.
- These are only made economically upon request and may not be meant for civilian use.

According to a 2007 study by Rayan and Singh, defense spending contributes both directly and indirectly to national revenue, which is in line with Keynesian consumption theory. However, Smith (1977) maintained that a sound theory must exist in order to explain the empirical findings of any study, even if it cannot be validated independently.

Sadly, there is currently no economic theory explaining how defense spending affects the economy. According to Deger and Smith (1983), formal education is likely to impede economic growth even though its goal is to raise defense spending. The thesis is predicated on the idea that a rise in defense expenditures signals a fall in private consumption, savings, and investment because of weak aggregate demand. Stated differently, higher military spending will raise interest rates, potentially outpacing private investment. According to the Keynesian school, higher defense spending can create positive

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3/Empirical Study

3-1 Descriptive Analysis

For the years 2000–2018, we use annual data from eight major industrialized nations (Canada, France, Germany, Italy, Japan, and the United Kingdom) and balance data from eight other nations.

The descriptive data for the following five variables are summarized in Table 1: education, R&D expenditure as a percentage of GDP (DepRDV), R&D per million population (CherRDEV), and information and communication technology (ICT). The World Bank's World Development Indicators was used to download the variables for government spending as a percentage of GDP (DepEDUC) and military spending as a percentage of GDP (DepMIL).

The ICT variable has a maximum value of 22.70243 and a minimum value of 0.167478, as seen in Table 1. CHERRDEV has the biggest standard deviation (SD), whereas DEPMIL has the lowest. Most variables have positive skewness values, suggesting that the distribution is skewed to the right and there are several observations on the left. Every variable utilized in the analysis has a normal distribution, according to Jarque-Bera statistics. Information and communication technologies (ICT) have a minimum value of 0.167478 and a maximum value of 22.70243 across all countries. For every variable, there are 144 observations.

Table 1: Descriptive statistics

Tableau	ICT	DEPRDEV	CHERRDEV	DEPEDUC	DEPMIL
Mean	6.533741	2.054756	3718.595	11.05336	2.112331
Median	4.561297	2.026410	3890.897	10.86566	1.756077
Maximum	22.70243	3.400220	5332.617	13.83690	5.452407
Minimum	0.167478	1.005460	1153.879	7.808570	0.897627
Std. Dev.	5.325399	0.709423	1017.217	1.679504	1.087815
Skewness	1.053183	0.141435	-0.726881	0.037653	0.876765
Kurtosis	3.386635	1.826526	3.212941	1.726056	2.799870
Jarque-Bera	27.51757	8.742344	12.95261	9.771621	18.68953
Probability	0.000001	0.012636	0.001539	0.007553	0.000087
Sum	940.8586	295.8849	535477.6	1591.683	304.1756
Sum Sq. Dev.	4055.462	71.96911	1.48E+08	403.3647	169.2178
Observations	144	144	144	144	144

Table 2: Correlations between variables

	ICT	CHERRDEV	DEPEDUC	DEPMIL	DEPRDEV
ICT	1.000000	-	-	-	-
CHERRDEV	0.381054	1.000000	-	-	-
DEPEDUC	0.159491	0.254668	1.000000	-	-
DEPMIL	-0.072862	-0.208844	0.457980	1.000000	-

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DEPRDEV	0.621398	0.725328	-0.060954	-0.264611	1.000000

Unit Root Test

We check for the presence of a "unit root" in the entire sample from 2000 to 2018 in order to examine the stationarity of variables.

Whether or not a process is stationary determines which model should be used. If the series being studied is derived from a stationary process, we often look for the best model to represent it in the class of stationary processes and then estimate this model.

On the other hand, we must look for a stationary transformation of the non-stationary process from which the series originates in order to "stationarize" it. After that, we'll model it and calculate the stationary component's properties.

However, non-stationarity can come from a variety of sources, and each one is linked to a certains stationarization techniques.

There are two ways to differentiate between the ideas of stochastic and deterministic non-stationarity, nevertheless, if one is curious:

Statistically

and economically.

Statistically, the type of modeling and the asymptotic characteristics of the associated econometric techniques depend on whether the series being utilized is stationar or non-stationar. For instance, in the case of a DS process, disregarding these particular asymptotic features might result in diagnostic errors and models that are wholly deceptive.

Economically: Trend/cycle decomposition approaches are generally being questioned as a result of the discovery of stochastic non-stationarity.

In the literature, a number of panel unit root tests have been put out, such as Im et al. (2003), Breintung (2000), and Maddala and Wu (1999).

Using a large-scale Monte Carlo simulation, Hlouskova and Wagner (2006) have discovered that, out of all the panel unit root tests, the Breitung (2000) test had the largest bias and the smallest distortion size.

The Im-Pesaran-Shin (IPS), Levine-Lin-Chu (LLC), Im-Pesaran-Chu (Im, Pesaran, and Shin, 2003), and Levine-Lin-Chu (Levine, Lin, and Chu, 2002) tests can be used to confirm the order of integration and identify the point at which the time series variable becomes stationary. Based

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on the ideas of the traditional Augmented Dickey-Fuller (ADF) test, the LLC and IPS approaches were both put into practice. While the IPS technique investigates intercept and slope coefficient variability, the LLC method examines intercept heterogeneity among group members. Both tests were applied by the ADF individual means statistic across section units. The test follows the estimation using the following equation:

$$\Delta Y_t = \mu_i + \gamma_i Y_{it-1} + \sum_{j=1}^{pi} \beta_{ij} \Delta Y_{it-j} + \delta_i t + \varepsilon_{it}$$

For all i and t, εit denotes normally and independently distributed random variables with zero means and finite heterogeneous variances (σ_i^2).

i = 1,2...N; t = 1,2...T; pi is the number of lags retained for the ADF regression; Δ is the first difference (1-L); and Yit is the series for country i in the panel over period t.

For the eight countries, Table 3 shows the potential for a long-term equilibrium relationship between ICT, research and development spending as a percentage of GDP (DepRDV), R&D researchers per million people (CherRDEV), public education spending, total as a percentage of GDP (DepEDUC), and military spending as a percentage of GDP (DepMIL). We shall discuss the presence of long-term associations below, as all variables are stationary in first difference.

Table 3: Unit root tests

	ICT	CHERRDEV	DEPEDUC	DEPMIL	DEPRDEV
At level (au niveau)					
Method					
Levin, Lin & Chu t*	-0.04043 (0.4839)	-1.41197 (0.0790)	-0.48355 (0.3144)	-9.59686* (0.0000)	-1.37979 (0.0838)
Im, Pesaran and Shin W-stat	-0.06770 (0.4730)	-0.92048 (0.1787)	0.13741 (0.5546)	-8.55293* (0.0000)	-1.64413 (0.0501)
ADF - Fisher Chi-square	19.5447 (0.3590)	25.4408 (0.1851)	19.0705 (0.5172)	103.917* (0.0000)	28.1249 (0.1065)
PP - Fisher Chi-square	29.2078 (0.0459)	21.4638 (0.3703)	13.5625 0.8520	122.533* (0.0000)	36.8897 0.0121
firstdifference (1er deffirence)					
Levin, Lin & Chu t*	-11.4079* (0.0000)	-10.8489* (0.0000)	-7.30969* (0.0000)	-15.6458* (0.0000)	-13.8300* (0.0000)
Im, Pesaran and Shin W-stat	-8.52880* (0.0000)	-10.7814* (0.0000)	-5.82153* (0.0000)	-14.6744* (0.0000)	-12.3422* (0.0000)
ADF - Fisher Chi-square	101.692* (0.0000)	125.542* (0.0000)	69.4351* (0.0000)	186.152* (0.0000)	149.588* (0.0000)
PP - Fisher Chi-square	102.193* (0.0000)	140.970* (0.0000)	91.9282* (0.0000)	968.332* (0.0000)	183.442* (0.0000)

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Note: ** represents significance at the 1% of significance (bold entries). The null hypothesis is that the variable follows a unit root process*

3.2 Cointegration analysis

Cointegration analysis, first introduced by Granger (1983) and Engle and Granger (1987), is regarded by many economists as one of the most significant new ideas in econometrics and time series analysis

This phrase describes the circumstance in which two or more non-stationary time series are connected in a way that prevents them from diverging over an extended period of time. After that, there are one or more stationary linear combinations of these integrated time series of order I(1) or 1(0). Cointegrating equations are what these combinations are known as.

One of the most interesting approaches for testing the cointegration of a group of time series is the maximum likelihood method proposed by Johansen (1988, 1991). This approach is based on the Vector Autoregressive (VAR) model and has the advantage of not being limited to two series, allowing us to test for the existence of multiple cointegrating relationships.

Our goal at this point in the study is to identify the type and direction of any causal relationships that might exist between the variables examined for each of the nations in our sample. Descriptive statistics of the chosen variables are the first step in this process.

We will perform a cointegration analysis by Pedroni (2004) and Kao (1999) after examining the stationarity of variables. This will enable us to include the issues of non-stationarity of series into the multivariate analytic framework. The primary goal of this analysis is to find a cointegration vector and remove its impact. Granger (1969) created the cointegration test, which we apply to identify potential cointegration correlations between the variables in our panel.

When figuring out the long-term correlations between variables, this is the most pertinent. The fundamental principle of this cointegration is straightforward: two non-stationary series are cointegrated if their differences are in the same order. The variables in two or more series can be seen as being in a long-term equilibrium relationship if they are cointegrated (Engle and Granger, 1987). In contrast, a lack of cointegration means that the variables have no long-run link; hence, in principle, the posited variables can arbitrarily move

The following is a model of Pedroni (2004) empirical cointegration test equation:

$$\boldsymbol{TIC_{it}} = \boldsymbol{\varphi_{it}} + \boldsymbol{\gamma^{t}{}_{i}} + \boldsymbol{\varphi_{1t}}\mathbf{TIC}_{it} + \boldsymbol{\varphi_{2t}}\mathbf{CHERRDEV}_{it} + \boldsymbol{\varphi_{3t}}\mathbf{DEPEDUC}_{it} + \boldsymbol{\varphi_{4t}}\mathbf{DEPMIL}_{it} + \boldsymbol{\varphi_{5t}}\mathbf{DEPRDEV}_{it} + \boldsymbol{\mu_{it}}$$

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With i = 1,2, ..., n denotes each country in the panel, t = 1,2,........., N and denotes the time period to be used in the panel.

These cointegration tests, which comprise three group statistics and four round statistics, make up the Pedroni panel cointegration test.

If these statistics are able to rule out the possibility of no cointegration, then there is cointegration between the variables. Table 4 provides specifics on the Pedroni cointegration test findings.

The null hypothesis that there is no cointegration relationship for our panel is rejected in the majority of tests based on the Pedroni test findings shown in Table 4.

Table 4: Pedroni and Kao cointegration tests

PedroniResidualCointegration Test				
Series: ICT DEPMIL DEPEDUC DEPRDEV CHERRDEV				
Sample: 2000 2017				
Alternative hypothesis: common AR coefs. (within-dimension)				
			Weighted	
	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	2.593580	(0.0047)	-0.165624	(0.5658)
Panel rho-Statistic	2.642300	(0.9959)	2.898061	(0.9981)
Panel PP-Statistic	-9.316459	(0.0000)	-1.677633	(0.0490)
Panel ADF-Statistic	-3.824973	(0.0001)	-0.467798	(0.3200)
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	3.766250	(0.9999)		
Group PP-Statistic	-12.96458	(0.0000)		
Group ADF-Statistic	-1.775344	(0.0379)		
Kao (1999)	ADF	-5.421379*	(0.0000)	

Notes: *, ** indicate the rejection of the null hypothesis (H0) at 1%, 5%, where the H0 is that the variables are not cointegrated

3.3 Causal Analysis

Finding the causes of the phenomenon being studied is the goal of the causal analysis method. Here, the concept of causation is understood in a statistical context. A phenomenon that statistically favors the occurrence of effect e is called a cause.
In other words, the graphic shows that the existence of because c increases the frequency of consequence e, as demonstrated by a number of similar observations:

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We must fulfill some requirements in order to apply this causal analysis method, such as gathering comparable data on a group of items. This comparability makes it possible to analyze data quantitatively. Individuals, organizations, institutions, societies, or other kinds of units are the elements that are most frequently observed.

Granger (1969) developed the Granger causality test, which is commonly used to investigate the causal link between variables. Granger causality is a test that looks at the connections and direction of causal interactions between variables, whereas cointegration tests are unable to identify the direction of causation. When the variables are cointegrated, the causality test based on a vector autoregressive (VAR) model will overlook the first differences, as demonstrated by Engle and Granger (1987).

This method integrates all variables of order 1, or I (1). By adding a period to the regression of the vector autoregressive (VAR) model in terms of error correction, we identify a model with a dynamic error correction representation to estimate a vector error correction (VEC) model. The following regressions serve as the foundation for the dynamic error correction model, which finds causal relationships in panel data (Apergis and Payne, [2009]).

$$\Delta ICT_{it} = \alpha_{i1} + \sum_{p-1}^{k} \mu_{1ip}\, \Delta \mathrm{ICT}_{it-p} + \sum_{p-1}^{k} \beta_{1ip} \Delta \mathrm{CHERRDEV}_{it-p} + \sum_{p-1}^{k} \gamma_{1ip} \Delta \mathrm{DEPEDUC}_{it-p} + \sum_{p-1}^{k} \delta_{1ip}\, \Delta \mathrm{DEPMIL}_{it-p} + \sum_{p-1}^{k} \theta_{1ip} \Delta \mathrm{DEPRDEV}_{it-p} + \varphi_{1i} ECT_{it-1} + \varepsilon_{1it}$$

$$\Delta CHERRDEV_{it} \alpha_{i2} + \sum_{p-1}^{k} \mu_{2ip}\, \Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{2ip} \Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{2ip} \Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{2ip}\, \Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{2ip} \Delta DEPRDEV_{it-p} + \varphi_{2i} ECT_{it-1} + \varepsilon_{2it}$$

$$\Delta DEPEDUC_{it} = \alpha_{i3} + \sum_{p-1}^{k} \mu_{3ip}\, \Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{3ip} \Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{3ip} \Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{3ip}\, \Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{3ip} \Delta DEPRDEV_{it-p} + \varphi_{3i} ECT_{it-1} + \varepsilon_{3it}$$

$$\Delta DEPMIL_{it} = \alpha_{i4} + \sum_{p-1}^{k} \mu_{1ip}\, \Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{4ip} \Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{4ip} \Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{4ip}\, \Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{4ip} \Delta DEPRDEV_{it-p} + \varphi_{4i} ECT_{it-1} + \varepsilon_{4it}$$

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$$\Delta DEPRDEV_{it} = \alpha_{i5} + \sum_{p-1}^{k} \mu_{5ip}\, \Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{5ip} \Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{5ip} \Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{5ip}\, \Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{5ip} \Delta DEPRDEV_{it-p} + \varphi_{5i} ECT_{it-1} + \varepsilon_{5it}$$

The lag order is established by the Schwarz information criterion, and the estimation parameters are α, μ, β, γ, δ, θ, ϑ, ρ, σ, φ a, ω, where is the difference operator and the error correction term from the long-run cointegration relationship.

In order to determine whether Granger causality extends from research and development expenditure (RDE) to information and communication technology (ICT), the null hypothesis is: β_1ip=0, for all (i) and (p); This hypothesis implies that the value of the previous (ICT) has a large linear predictive effect on the current value of (RDE) if it is rejected, that is, if β_1ip is different from zero. According to this theory, (ICT) Granger influences (RDE), and vice versa. Information and communication technologies (ICT) and research and development expenditure as a percentage of GDP (DepRDV) are bidirectionally causative, with a 5% significant level in the short and long run, according to the estimation results shown in Table 5. Indeed, it is commonly acknowledged that internal and external R&D efforts are what propel technological advancement. Growth levels of R&D investment are regarded trustworthy measures of innovation capacity.

These findings also show that, although they depend on R&D spending and utilization, labor productivity levels are favorably correlated with technological innovation. Furthermore, the findings clearly indicate that organizational innovation is essential to productivity and R&D levels.

These findings also support the idea that improved value added across all industries should emerge from increased R&D spending in the ICT industry. When compared to research and development expenditure, the other study variables military and educational spending have no discernible effects. Additionally, at the 10% level, there is a unidirectional causal association between ICT and education spending. All things considered; the analysis shows that these kinds of nations have a lot of potential to boost ICT effectiveness to enhance their educational results.

Table 5: The VECM Granger causality analysis

Short- run (court terme)						Long - run
Excluded variables: block exogeneity (variables exogène)						
	ICT	CHERRDEV	DEPEDUC	DEPMIL	DEPRDEV	ECM_{t-1}
ICT	-	1.7391 (0.6283)	2.7880 (0.4255)	4.4983 (0.2124)	7.2726*** (0.0637)	-1.2736* [-6.8597]
CHERRDEV	0.1740 (0.9817)	-	5.7490 (0.1245)	1.6849 (0.6403)	0.7150 (0.8697)	-0.4309 [-1.2299]

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DEPEDUC	6.2710*** (0.0991)	9.3330** (0.0252)	-	7.4224*** (0.0596)	5.4446 (0.1420)	0.0055 [0.3893]
DEPMIL	4.1845 (0.2422)	3.2218 (0.3587)	4.4896 (0.2132)	-	6.9263*** (0.0743)	-0.6622 [-1.3013]
DEPRDEV	17.896* (0.0005)	8.1271** (0.0435)	2.8295 (0.4187)	1.5531 (0.6701)	-	-0.5754* [-3.2380]

Notes: *ECT represents the coefficient of the error correction term. *, **, and *** indicate that the parameter estimates are significant at the 1%, 5% and 10% levels respectively.*

4/ Results and Recommendations

Our empirical findings imply that research and development (R&D) and education spending are important drivers of ICT innovation. According to "new growth theories," this suggests that fostering these elements will promote the innovation of ICT technologies and ease their spillover effects. This is in line with theoretical conclusions about how R&D and technological innovation are related. Furthermore, the results of earlier empirical research (Castellacci and Natera, 2013; Furman et al., 2002; Hu and Mathews, 2005) are in line with this outcome. results. A nation's financial status is reflected in its social and economic growth. ICT innovation can be explained by this statiscally significant factor.

However, it is very important to remember that high income levels have led to high R&D investment and, in turn, high levels of ICT innovation.

It should be mentioned that the findings of this study support the findings of earlier empirical research, demonstrating that education is likewise statistically significant (Castellacci and Natera, 2013; Furman et al., 2002; Varsakelis, 2006). This implies that knowledge and human capital for ICT innovation are provided by education.

A country's capacity to adopt cutting-edge foreign technologies may be influenced by its educationally attainment (Castellacci and Natera, 2013).

Additionally, the research suggests that education helps develop a nationwide pool of entrepreneurs who, in order to become competitive, seek innovation and more effective Production techniques (Varskelis 2006).

The innovation system must be taken into consideration while evaluating the role of higher education. Indeed, in addition to its conventional function as a supplier of skilled labor and advanced knowledge, academia has contributed to corporate innovation and regional growth.

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5/Conclusion

First, in the developed G8 nations, the majority of the ICTs under study are still in the early stages of adaption. Government assistance, in the form of ICT-facilitating programs, must to be prioritized and reinforced going forward.

Second, technical information also demands a modernized platform to advance high-tech technologies and enhance technological infrastructure, both of which positively affect the factors that determine ICT in G8 nations. To be more precise, there are a number of factors that influence ICT, including R&D expenditures and researchers, public education spending as a percentage of GDP in industrialized nations, and military spending as a GDP percentage. These factors are first investigated theoretically, and then they are examined empirically in a study on the factors influencing ICT in industrialized nations.

In order to reap the most benefits, it is critical to make ICT more accessible and to create the methods needed to use it properly. Since acting on capacities and skills is required to properly profit from these new technologies, efforts must be taken in regards to access to the ICT platform.

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